North American Mesoscale Convective Systems Under Climate Change

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Severe convective storms in the form of Mesoscale Convective Systems (MCSs) increased in frequency and intensity during the past 35 years in the U.S. causing fatalities and rapidly increasing economic losses. However, future climate change impacts on MCSs are largely unknown because traditional climate models cannot simulate them. A North American-scale convection-permitting climate model allows us to simulate realistic MCSs in the current climate and at the end-of-century under a high-end emission scenario (RCP8.5) by assuming similar synoptic-scale conditions in both periods (pseudo global warming). Using a storm tracking algorithm we show that the model is able to accurately reproduce the main characteristics of current MCSs, such as their size, propagation speed, maximum rainfall, and total rainfall volume in the present climate. At the end of the century, the number of intense MCSs are projected to more than triple in North America during summer due to more favorable environmental conditions. In particular, MCSs have higher cloud tops, increased vertical moisture fluxes, and a significantly deeper warm cloud layer (distance from cloud base to freezing level). Changes in the MCS's dynamics, thermodynamics, and cloud microphysics lead to a 15-40 % increases in maximum hourly precipitation rates and a significant spreading in heavy precipitation areas result in up to 80 % higher MCS total precipitation volume. Volume increases are most pronounced in a 40 km radius around the storm center, which is the scale of large cities and mesoscale river catchments. The potential implication on future flood risk will be discussed.